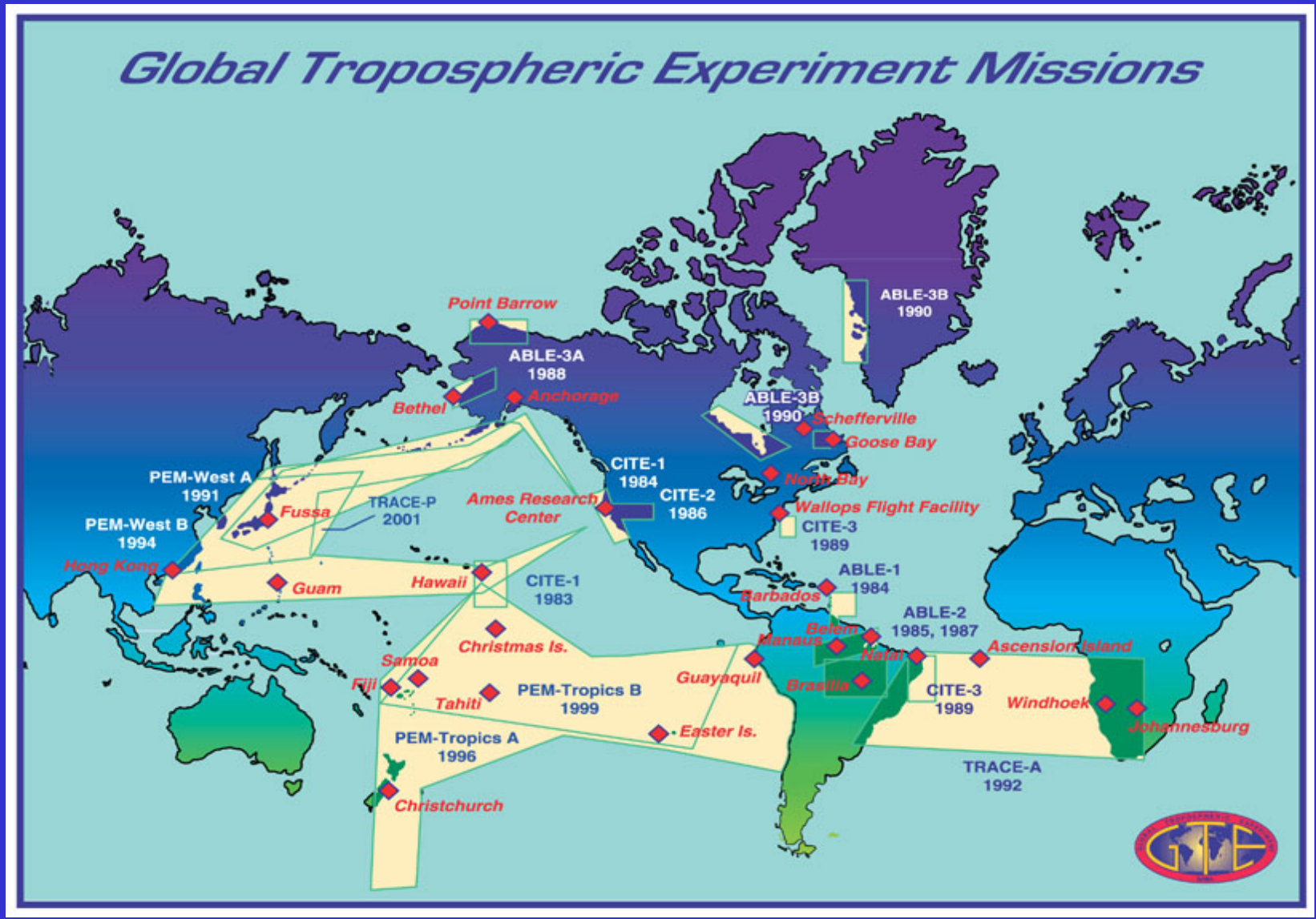
NASA/GTE MISSIONS, 1983-2001



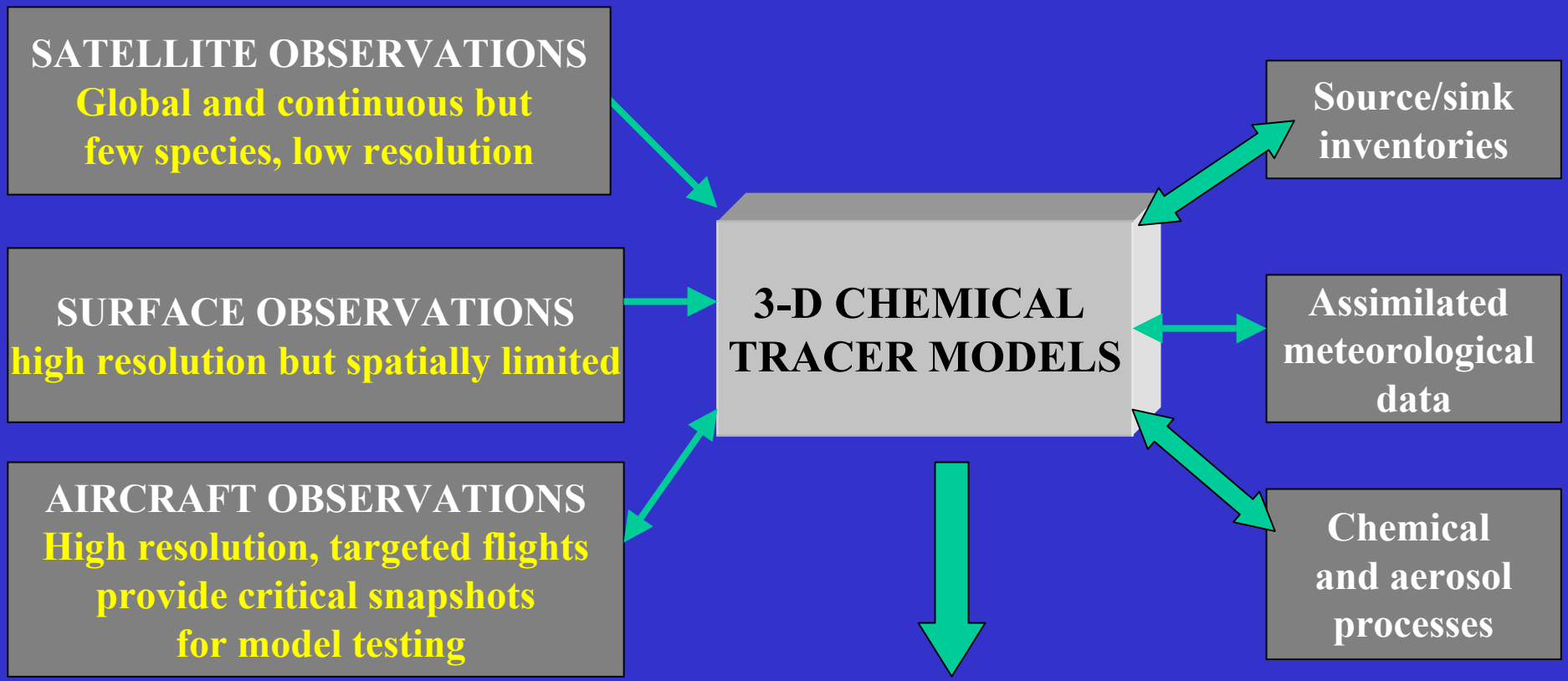
TRAnsport and Chemical Evolution over the Pacific (TRACE-P)
26 February – 10 April 2001

MISSION OBJECTIVES

- to determine the chemical composition of the Asian outflow over the western Pacific in spring in order to understand and quantify the export of chemically and radiatively important gases and aerosols, and their precursors, from the Asian continent.

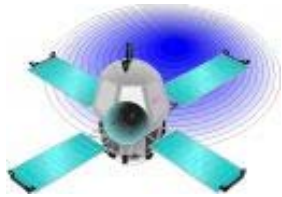
- to determine the chemical evolution of the Asian outflow over the western Pacific in spring and to understand the ensemble of processes that control this evolution.

TRACE-P INVOLVED THE INTEGRATION OF AIRCRAFT, SATELLITES, AND MODELS



ASIAN OUFLOW FLUXES

TRACE-P EXECUTION



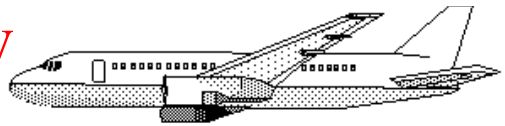
Satellite data
in near-real time:
MOPITT
TOMS
SEAWIFS
AVHRR
LIS

Stratospheric
intrusions

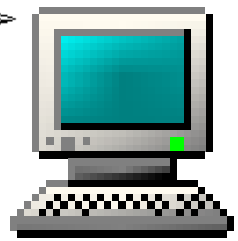
FLIGHT
PLANNING

Long-range transport from
Europe, N. America, Africa

ASIAN
OUTFLOW



DC-8



3D chemical model
forecasts:
- ECHAM
- GEOS-CHEM
- Iowa/Kyushu
- Meso-NH
-LaRC/U. Wisconsin

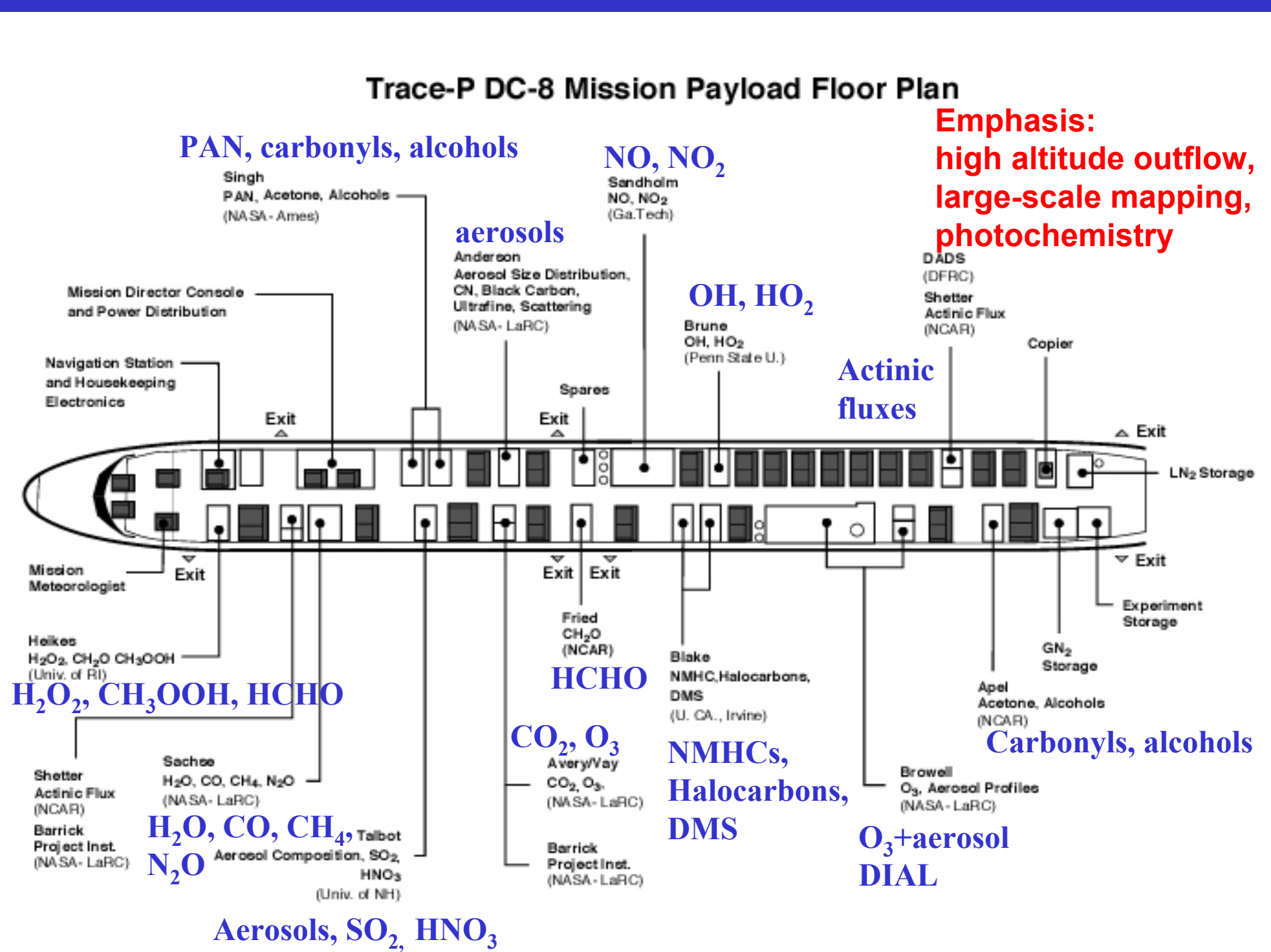
Boundary layer
chemical/aerosol
processing

P-3

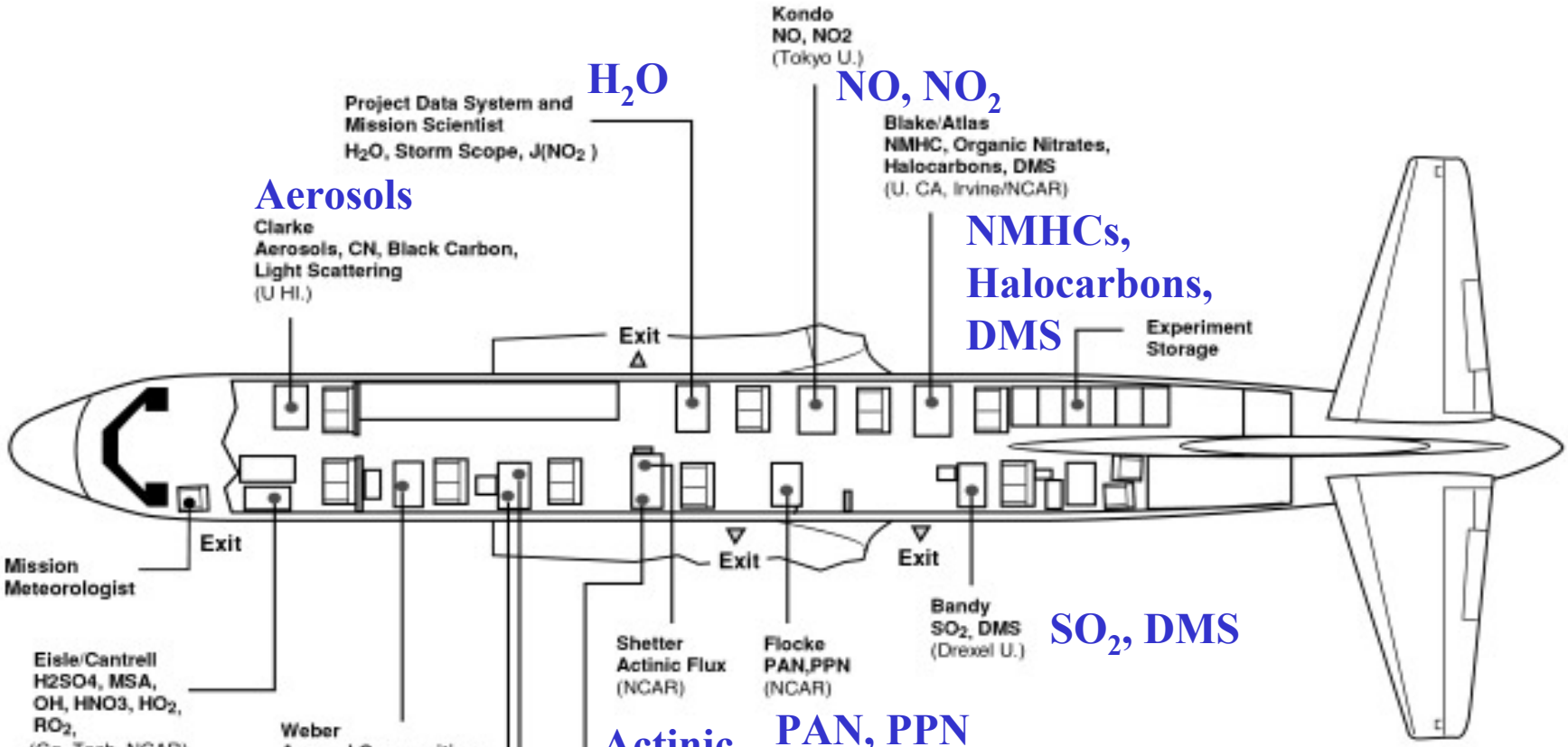
PACIFIC

ASIA

Emissions
-Fossil fuel
-Biomass burning
-Biosphere, dust


Trace-P DC-8 Mission Payload Floor Plan
Emphasis:
high altitude outflow,
large-scale mapping,
photochemistry
PAN, carbonyls, alcohols
Singh
PAN, Acetone, Alcohols
(NASA - Ames)
NO, NO2
Sandholm
NO, NO2
(Ga.Tech)
aerosols
Anderson
Aerosol Size Distribution,
CN, Black Carbon,
Ultrafine, Scattering
(NASA - LaRC)
OH, HO2
Brune
OH, HO2
(Penn State U.)
DADS
(DFRC)
Shetter
Actinic Flux
(NCAR)
Actinic
fluxes
Copier
Mission Director Console
and Power Distribution
Navigation Station
and Housekeeping
Electronics
Spares
Exit
LN2 Storage
Experiment
Storage
Mission
Meteorologist
Heikes
H2O2, CH2O CH3OOH
(Univ. of RI)
Fried
CH2O
(NCAR)
HCHO
H2O2, CH3OOH, HCHO
Blake
NMHC,Halocarbons,
DMS
(U. CA., Irvine)
GN2
Storage
Apel
Acetone, Alcohols
(NCAR)
Carbonyls, alcohols
CO2, O3
Avery/Vay
CO2, O3,
(NASA - LaRC)
NMHCs,
Halocarbons,
DMS
Shetter
Actinic Flux
(NCAR)
Barrick
Project Inst.
(NASA - LaRC)
Sachse
H2O, CO, CH4, N2O
(NASA - LaRC)
H2O, CO, CH4,
N2O
Talbot
Aerosol Composition, SO2,
HNO3
(Univ. of NH)
Barrick
Project Inst.
(NASA - LaRC)
Browell
O3, Aerosol Profiles
(NASA - LaRC)
O3+aerosol
DIAL
Aerosols, SO2, HNO3

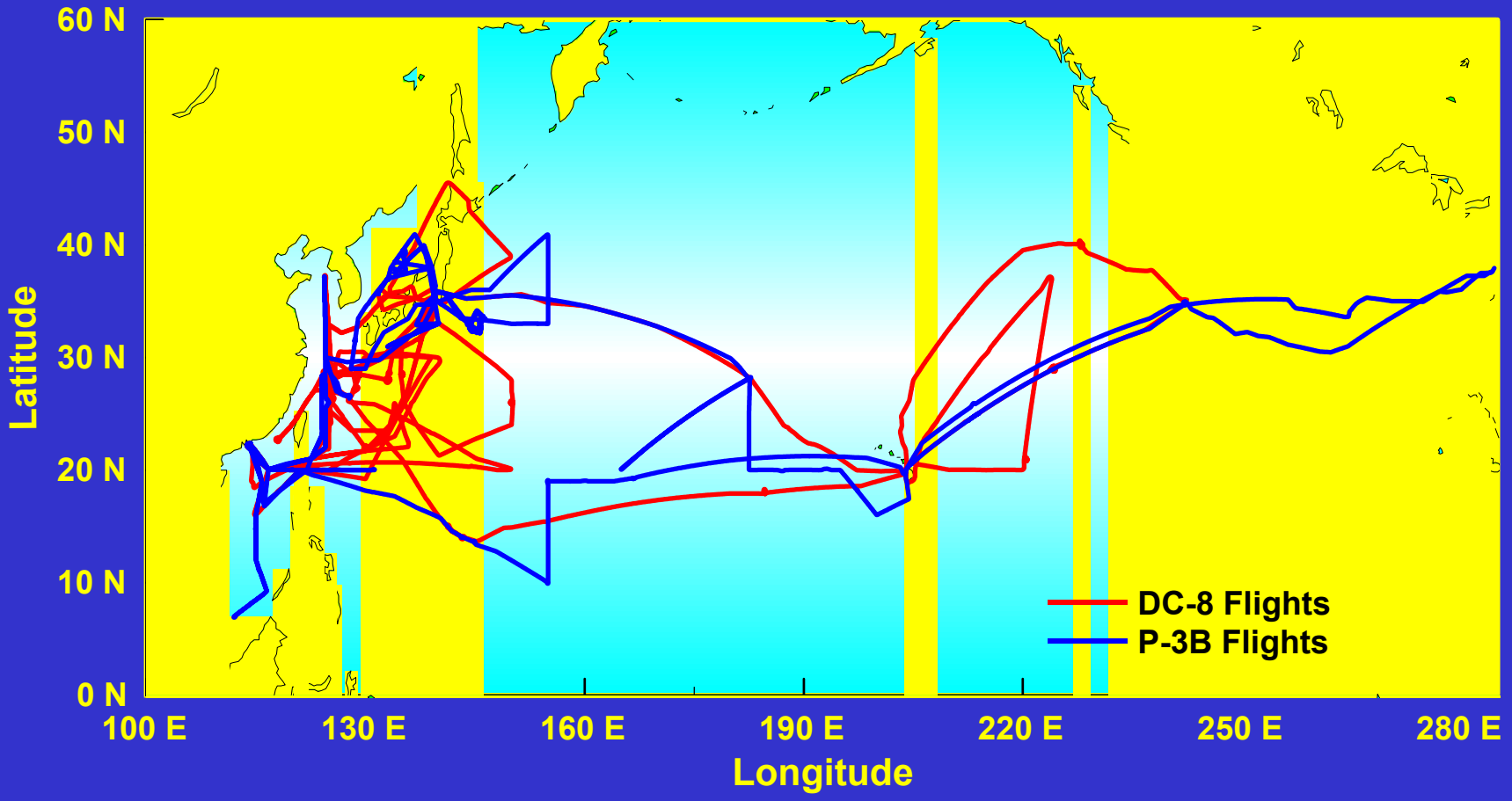
Trace-P P-3B Mission Payload Floor Plan



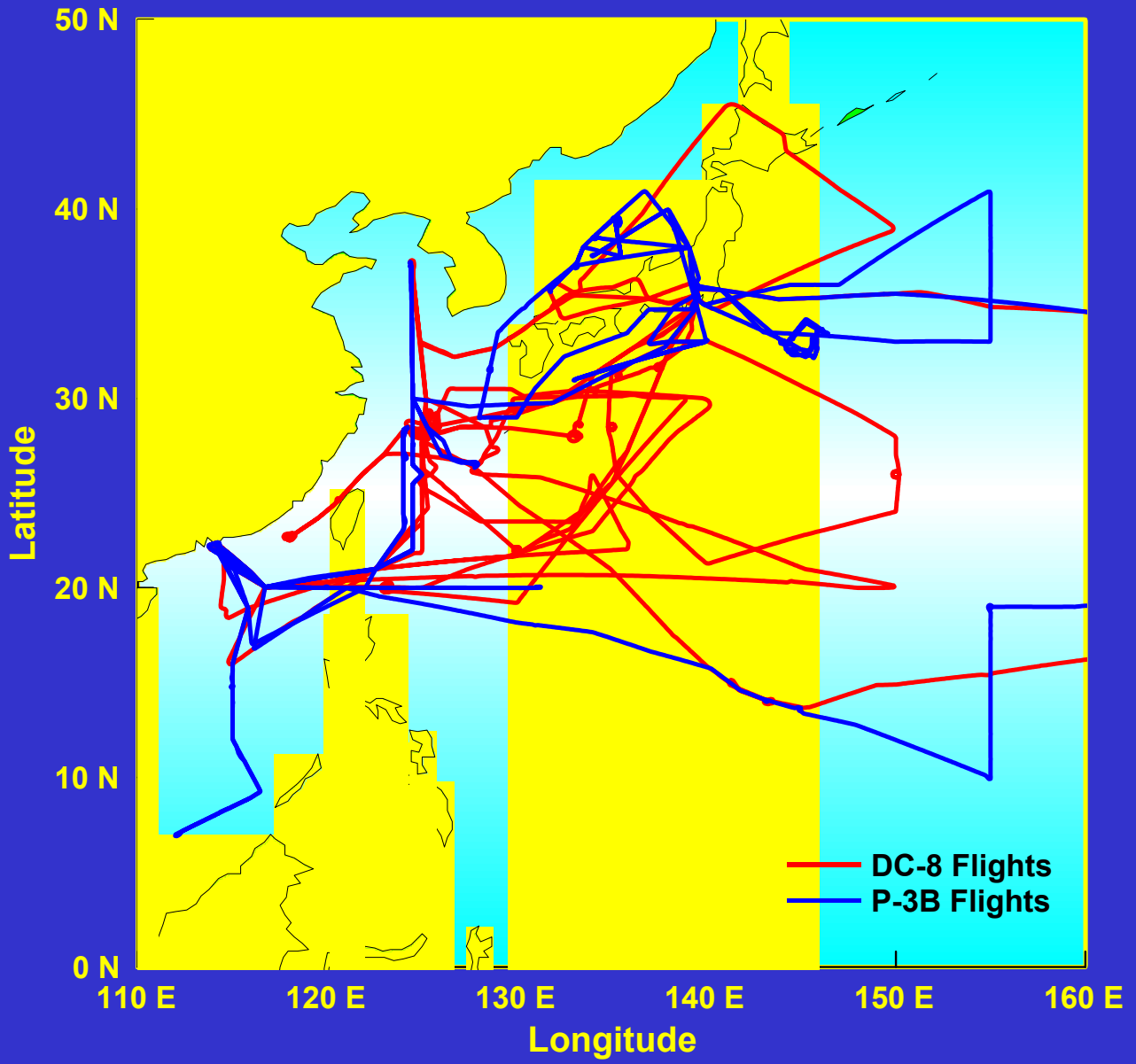
Emphasis:
low altitude outflow, sulfur/aerosols, fluxes to ocean

02.07.01JC

TRACE-P FLIGHT TRACKS



FLIGHT TRACKS ALONG THE PACIFIC RIM DURING TRACE-P

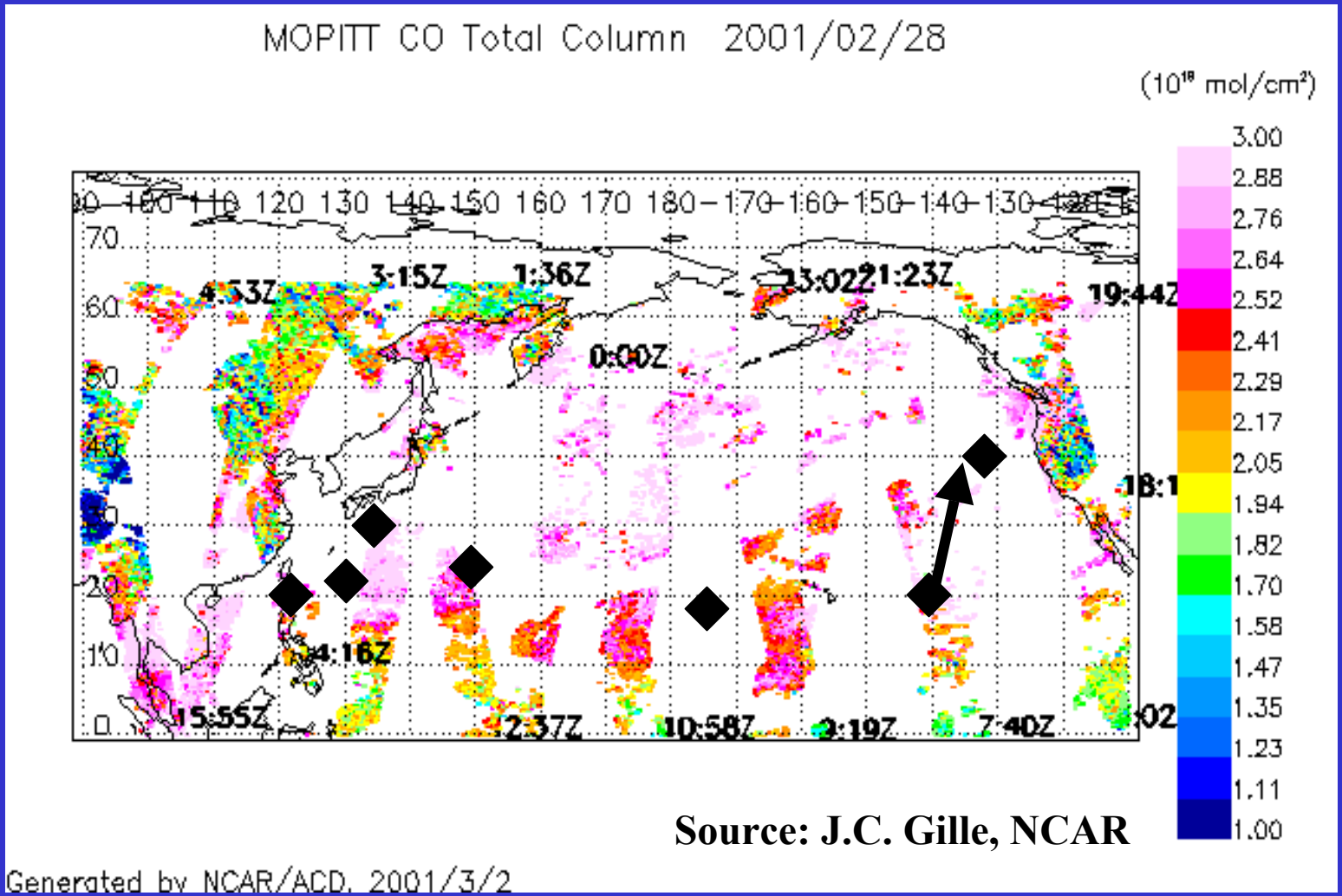


TRACE-P COORDINATION WITH ACE-ASIA

- Two joint Asian outflow chemical characterization flights between the TRACE-P P-3 and the ACE-Asia C-130 out of Japan including a Terra underpass on each flight.

- One DIAL overpass of the ACE-Asia Twin Otter by the TRACE-P DC-8 during a column radiation closure experiment over the Sea of Japan

MOPITT near-real time CO column data: diamonds show validation experiments during TRACE-P



MOPITT validation spirals

MOPITT validation transect (following orbit track)

MAJOR QUESTIONS FOR TRACE-P: AIR MASS CHARACTERIZATION

- **What are the important air masses and transport pathways contributing to Asian outflow to the Pacific?**
  - **What are the important mechanisms for export of Asian pollution to the Pacific?**
  - **What are the roles of topography, frontal lifting, convection in delivering Asian emissions to the free troposphere?**
  - **What is the contribution of biomass burning to the outflow, and how does it overlap with contributions from other sources?**
  - **What is the contribution of stratospheric air to the outflow, and how does it overlap with contributions from other sources?**
  - **Is there evidence for outflow of European or African air masses?**
  - **How does the chemical composition of the Asian outflow evolve during transport across the Pacific?**
  - **How does 2001 compare to other years? What is the role of ENSO?**

MAJOR QUESTIONS FOR TRACE-P: AEROSOLS

- **What are the sources and properties of aerosols over the western Pacific, and what are their effects on the chemical evolution of Asian outflow?**
  - **What are the major sources of aerosols over the western Pacific?**
  - **What are the sources and sinks of SO_2 over the western Pacific?**
  - **Are the dust observations in TRACE-P consistent with our understanding of sources?**
  - **What are the optical and hygroscopic properties of the aerosols? How do different aerosol types contribute to radiative forcing?**
  - **Are the observations of H_2SO_4(g) and ultrafine aerosols consistent with our understanding of aerosol nucleation?**
  - **What processes determine the evolution of the aerosol size distribution?**
  - **How do aerosols affect the photochemical evolution of the Asian outflow?**
  - **What is the partitioning between $HNO_3$and aerosol nitrate?**
  - **What is the evolution of the aerosol composition and outflow from March to May (from TRACE-P to ACE-Asia)?**

MAJOR QUESTIONS FOR TRACE-P: FAST PHOTOCHEMISTRY

- **What processes determine radical concentrations in Asian outflow?**
  - Are the observed HO_x concentrations consistent with current understanding?
  - Are the observed concentrations of peroxides and formaldehyde consistent with current understanding?
  - Is the observed NO/NO_2 ratio consistent with current photochemical understanding?
  - Is there closure on the NO_y budget?
  - What processes control the chemical sources and sinks of NO_x?
  - How does deep convection affect the supply of HO_x and NO_x to the upper troposphere?
  - What are the chemical regimes and rates for ozone production?
  - What is the effect of acetaldehyde and higher carbonyls on the HO_x and NO_x budgets?
  - Is there evidence for halogen radical oxidants?

MAJOR QUESTIONS FOR TRACE-P: OXYGENATED AND OTHER FUNCTIONAL ORGANICS

- **What are the abundances and sources of oxygenated organics, organic nitrates, halocarbons, nitriles in Asian outflow and in clean marine air over the Pacific?**
  - **What are the sources/sinks of acetaldehyde, acetone, other carbonyl compounds? (What is the role of air/sea exchange?)**
  - **What are the sources/sinks of alcohols?**
  - **What are the sources of organic nitrates?**
  - **What are the sources/sinks of nitriles?**
  - **What are the sources of methyl halides?**

MAJOR QUESTIONS FOR TRACE-P: SOURCE QUANTIFICATION

- **Can we use the TRACE-P aircraft observations to improve estimates of chemical sources and sinks of long-lived greenhouse gases, ozone and precursors, aerosols and precursors in eastern Asia?**
  - **What are the sources of CO_2, methane, N_2O from the Asian continent?**
  - **What are the magnitudes of ship emissions and the chemical evolution of the ship plumes?**
  - **What are the factors controlling the outflow and concentrations of ozone, NO_x, and NO_y over the western Pacific?**
  - **Can we use the TRACE-P observations together with 3-D chemical tracer models to improve emission inventories in eastern Asia?**
  - **Can the integration of satellite and aircraft observations (MOPITT, GOME, TOMS) provide additional information to constrain sources and transport of CO, ozone and its precursors, and other species?**

MAJOR QUESTIONS FOR TRACE-P: METHODS

- **How successful was the integration of aircraft, satellites, and chemical transport models during TRACE-P?**
  - How do the in situ measurements from different instruments intercompare?
  - Can the TRACE-P observations be usefully integrated with observations from surface sites, ozonesondes, solar IR absorption measurements?
  - How useful were the chemical forecasts?
  - How do the 3-D chemical tracer simulations compare between themselves and with observations?
  - How useful is immersive analysis of observations and 3-D model output?
  - How useful were the MOPITT validation flights? Did we collect useful validation data for MISR or MODIS?
  - Can the MOPITT/TOMS/MODIS/MISR data be usefully integrated with the aircraft data to extend coverage?
  - Can the TRACE-P observations be usefully integrated with the data sets from ACE-Asia, BIBLE, PHOBEA?